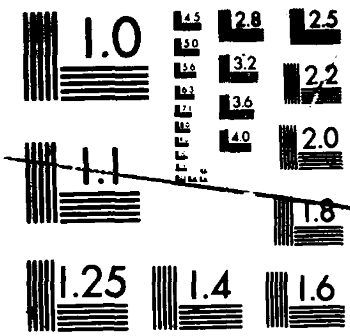
AD-A183 506 DESIGN DEVELOPMENT AND PLAY OF NAVY WARGAMES(U) CENTER FOR NAVAL ANALYSES ALEXANDRIA VA NAVAL WARFARE OPERATIONS DIV P P PERLA MAR 87 CNA-PP-450 1/1

UNCLASSIFIED F/G 12/5 NL

END
9-87
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Professional Paper 450 / March 1987

Design, Development, and Play of Navy Wargames

by

Peter P. Perla

A Division of CNA Hudson Institute

CENTER·FOR·NAVAL·ANALYSES

4401 Ford Avenue • Post Office Box 16268 • Alexandria, Virginia 22302-0268 • (703) 824-2000

Professional Paper 450 / March 1987

Design, Development, and Play of Navy Wargames

by

Peter P. Perla

Naval Warfare Operations Division

A Division of CNA Hudson Institute

CENTER·FOR·NAVAL·ANALYSES

4401 Ford Avenue • Post Office Box 16268 • Alexandria, Virginia 22302-0268 • (703) 824-2000

ABSTRACT

This paper describes some of the important elements of wargame design, development, and play. Wargame design is the art of creating a warfare model or simulation to be used in wargaming; wargame development is the process of testing and refining that model to make it more effective in achieving its objectives; and wargame play is the exercising of the model by becoming an integral part of it.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

A wargame is best defined as any warfare model or simulation, not involving actual military forces, in which the flow of events is affected by and, in turn, affects decisions made during the course of those events by players representing the opposing sides. Wargame design is the art of creating such a model; wargame development is the process of testing and refining that model to make it more effective in achieving its objectives. Playing a wargame involves actively exercising and, in effect, becoming an integral part of that model.

This paper describes some of the important elements of the design and development process. Although it proposes some guidelines for the process of game design, it is by no means a comprehensive textbook. Game design is more art than science; as such, it is best accomplished through a combination of designer ability and extensive practice and experience. In addition, playing in a wargame calls for the same sort of willing suspension of disbelief required in reading a novel; the artificialities of the game must be put aside, but never fully forgotten.

GAME DESIGN

Game design can take many forms. At one extreme, the game is produced from scratch for a very specific purpose; all elements of the game are developed expressly for its design. At the other extreme, the game is constructed out of already existing components; only the choice of which available pieces to use is necessary. Games designed for specific analytical purposes often tend toward the first form. Games designed at the Naval War College, building on their years of experience and extensive facilities, more often tend toward the second form. Most games will fall between the two extremes.

In any case, the goal of wargame design is to facilitate communications. The structure of the game consciously or unconsciously sends the sponsor's concerns and messages to the players through the medium of the designer's interpretation of the game's objectives and means of achieving them. The play of the game, in turn, transmits the players' concerns, interpretations, questions, and insights back to the sponsor, either directly or through the medium of game analysis.

Thus the fundamental questions the game designer must ask and answer are:

- What does the sponsor want to learn from the players?
- What does the sponsor want to say to the players?
- Who are the players that will be involved or that need to be involved, and what are their interests or concerns?
- How can the sponsor's and players' goals best be linked? In particular, what information must the game provide, and how can it be structured to do so?

Specifying the objectives of a game is fundamental to its design. This initial step is one in which sponsors, designers, and analysts must work together not only to identify the objectives, but also to define how and in what ways the game will help meet those objectives. Often, the sponsor's initial goals will be unclear, or the utility of gaming for achieving those goals uncertain. Once all parties involved have sharpened the definition of the

problem and agreed that the problem may be usefully addressed through a game, the design work can begin.

To build his design, the designer must define the infrastructure of the game; collect, refine, and distill the information required to play and control the game; and devise the mechanics through which the game will function. The infrastructure of the game may be thought of as consisting of four parts: the level, scope, and scale of the game; the number of players or teams; the amount of information available to players; and the format or style of the game. Information is basically of two types: the scenario and the data base. Mechanics similarly fall into two categories: models of combat or other operations, and procedures for the smooth playing of the game.

SPECIFYING THE OBJECTIVES

The reasons for designing a wargame may be placed into the broad categories of education and research. Education or training objectives may be further characterized as focusing primarily on providing an active learning experience of their own, reinforcing lessons taught in a more traditional academic setting, or evaluating the extent to which students have assimilated such lessons. Research objectives may also be divided into three classes: focusing on developing strategies, identifying issues, or building a consensus. Table 1 summarizes these game objectives. The focus of this paper is on research games. For a more detailed introduction to education and training games, see [1].

Navy research games have addressed all three types of research objectives just mentioned. The CNO's Strategic Studies Group (SSG) at the Naval War College uses gaming as an important element of its research into developing maritime strategies. The Global War Game series (see, for example, [2]) and special purpose games such as OP-603's Central Front/Maritime Option game [3] have contributed to the growth and development of the Navy's strategic thinking.

Identifying issues, although a basic goal of virtually all research games, is the major focus of a number of important Navy efforts. Chief among these is the POM Wargame series, sponsored by the Director of Naval Warfare (OP-095) [4]. In these and similar games, strategies are essentially fixed, and attention centers on systems or program-related issues arising from attempts to execute the strategy

TABLE 1

GAME OBJECTIVES

Educational games	Research games
• Learning new lessons	• Developing strategy
• Reinforcing old lessons	• Identifying issues
• Evaluating understanding	• Building a consensus

High-level games, such as those played by the CNO and Navy Commanders in Chief (CINCs) as well as the Joint Chiefs of Staff, are often useful in building a consensus. Such games can present a particular view of policy or strategy issues, air alternatives, and synthesize a common and broader understanding of the problems.

Each individual game has a unique set of specific objectives that often contain elements of all three research classes, and even those of training and education as well. It is impossible to list all such possible objectives and write a recipe for designing a game to achieve each. In what follows, however, readers will find some general ideas about how the different types of game objectives affect the design process.

DEFINING THE INFRASTRUCTURE

When designing a wargame, decisions must be made as to the numbers of players or "sides" there should be, how much information should be provided to the players, the format of the game (seminar or system game), and the scope or level of the game.

Number of Players

One of the first choices a designer must make is to determine whether the game should be a one-player, two-player, or multiplayer game. This terminology refers not to the actual number of persons playing the game (which in Navy games tends to be fairly large) but rather to the number of "sides" or independent contending parties. Most military games tend to have two

players, friendly and enemy (often called "Blue" and "Red"). Some educational games have only one player, with opposition provided or scripted by a control group that monitors most aspects of the game. Multiplayer games occur most frequently in political-military games in which each player represents a sovereign nation or alliance.

Because wargames are so detailed, complex, and specialized, it is rare that a single individual can play a side in the game. Typically, teams of several officers staff what are usually referred to as game cells. Such cells could represent the "watch" in a combat information center, the battle staff of a fleet commander, or the National Security Council. The actual number of persons involved in a cell depends on the information-processing and communications requirements the game levies on the cell, and on the wishes and resources of game sponsors, players, and facilities.

The key point for game design is to assign player cells to command positions of interest and importance to achieving the game's objectives. Command levels above and below these cells can be assumed by the game control staff. For example, a game focusing on theater-level operations may demand player cells at fleet and battle-group levels, with control staff assuming roles of the National Command Authority (NCA) and individual ship commanding officers.

Although the actual choice of numbers, expertise, and roles of individual cell members is not the designer's prerogative, game designers can facilitate the process by identifying the type of support likely to be necessary in the play of the game. Further, the game may be designed to abstract key elements of information distribution and decisionmaking to allow effective play with fewer people.

Problems may arise when considerations of cell-manning requirements are not given due weight. In a past Navy game focusing on theater-level operations, a single officer was tasked with responsibility for all operations in his theater. A pool of "expert witnesses" was provided to help the three theater players with suggestions and information. The result was confusion and lost time when a player could not locate a needed expert or when two players had similar requirements at the same time. A more recent game of this type altered the structure by forming the "expert witnesses" into staffs for each of the theaters, and the resulting flow of the game was much smoother.

Information Limits

To play a game, players need information. Some of this information resides in the data base and game scenario and is discussed in detail later. Other information arises during game play in the form of updates on the status and operations of friendly and enemy forces. There are two basic methods of providing this operational information to players: open and closed systems.

An open game is one in which all information is available to the players with no restrictions or distortions. Closed games allow the players to know only what their sensors or other friendly sources can provide them. In some cases, this information may be accurate; in others, it may be wildly incorrect.

Because actual military operations are often plagued by "the fog of war," wargames generally attempt to be at least partially closed in nature. Unfortunately, closed-game designs place heavy demands on the control group. To restrict player access to information, a filter must be placed between them and "ground truth," or game reality. The control group must screen and modify information to delay, confuse, and in some cases misrepresent what is actually happening in a manner approximating what players might experience in actual combat. Such games require large, well-trained, experienced control staffs, such as that at the Naval War College. The control staff must be well-practiced and disciplined at providing the quality and quantity of information the players deserve. In addition, players must be physically separated in a closed game, requiring greater space and more extensive facilities in general.

Despite the difficulties of managing a closed game, there are many important issues that simply cannot be explored with open gaming. Obviously, there is little insight to be gained about the roles of command, control, communications, and intelligence (C^3I) from a game in which players are given complete and perfect information.

Sometimes, however, good game design and good game players can overcome some of the problems of open games. These latter are often easier to execute, place less demands on the control group, and cause less frustrations to players. Although the uncertainties of closed games are eliminated, open games are by no means useless. Indeed, for many training and exploratory functions, open games can work quite well, so long as their artificialities are kept in mind. In the end, the tradeoff between open and closed games may be

dictated by the limitations of facilities and people, and the designer must find a way to limit the negative impacts such necessary restrictions may have on the game's effectiveness.

Format

Sometimes the choice of whether a game will be open or closed can be heavily influenced by the format or style of the game. Basically, there are two types of styles, the seminar game and the system game. The distinguishing characteristics of these two formats center around the degree of player interaction. If such interaction is direct, typically with players discussing their options and decisions in a seminar-like forum, the game is classed as a seminar game. If the player's interaction is indirect, through the media of umpires, models, computers, or other devices, the game is a system game. The latter type replaces direct discussion with a set of detailed rules and procedures for determining the interaction of player decisions and forces.

Seminar games are often open games; system games are often closed. However, this relationship is not a fixed one. Most commercially available hobby wargames are open games, but essentially all are system games. Similarly, some seminar games played by the military can incorporate at least some elements of closed gaming techniques.

Although it would seem that system games, especially closed system games, might be most appropriate in the defense arena, seminar games do have certain important advantages that assure their long-term popularity. First, seminar games allow a freer interchange of ideas among participants. Thus, in many ways, seminar games may be better suited to some training and education goals than system games. For the same reasons, seminar games tend to be more effective at helping groups of people arrive at a consensus about the desirability or feasibiltiy of certain courses of action.

System games are more rigid and perhaps in some ways more realistic than seminar games. However, there is a danger in system games that any departures from reality, due to mistakes in modeling or input values, or simply outdated structures, can be more difficult to detect and adjust than in the more open forum of a seminar game. Balancing the rigor of a system game with the flexibility of a seminar game to achieve the game's objectives is thus a critical element of game design art.

Scope, Level, and Scale

The final elements of a game's infrastructure are closely linked. The geopolitical scope of the game, the decision level of the players, and the scale of aggregation must fit into a coherent package—one that is consistent with the other elements of the game.

A successful game design often provides participants with well-defined operational roles, gives them corresponding geographical and operational responsibilities, and supplies them with the kind of information appropriate for carrying out their assigned functions. If an actual fleet commander generally receives reports and issues orders at the battle-group level, then the player cast in that role should do the same. Too much detail drops a player out of his role into that of a lower-level commander and limits his ability to operate, think, and decide in his primary role. Too little detail makes his decisionmaking process an uninformed one and severely restricts the insights that might result.

In rare cases, and to meet specific objectives, players may be forced to shift roles back and forth during game play, especially when the number of participants is limited. For example, to adequately address detailed tactical or systems issues in the context of a particular theater's operations, the theater commander might be required to also assume the role of a battle-group or air-strike commander for a short time or for a specific engagement. Juggling such role shifting and keeping the game on track is a tremendous challenge to the game designer.

ASSEMBLING THE INFORMATION

Earlier, it was noted that wargames enable game sponsors and participants to communicate in an iterative process. The process begins by placing players in the midst of a situation that requires them to make decisions. This setting is commonly referred to as the game's scenario. In addition to the setting, players must also receive information about the objects their decisions will affect, such as a measure of friendly and enemy capabilities, levels of supply, and some idea about the possible outcomes of various decisions players might make. This information comprises the game's data base.

Scenario

The term "scenario" has its origins in the theatrical world, where it usually refers to an outline or synopsis of the plot of a play, novel, or other work. Wargame scenarios set the scene for player decisions and provide for specific updates in the situation during play in order to alter or influence the developing situation and to elicit player responses to specific items of interest. By defining the setting and scope of player decisions, scenarios can direct the course of a game into very narrow or fairly broad channels, depending on the game's goals.

For example, a tactical education game dealing with the employment of surface-to-surface missiles may use a simple scenario in which a single friendly ship is tasked to engage a single enemy ship known to be operating in a well-defined region. In such a scenario, geopolitics, war aims, and other deep strategic considerations may be superfluous. A research game exploring warfighting and strategy issues for a global conflict will require a scenario focusing on just such high-level factors. Player decisions in the first case will be limited to those required to maneuver against, target, and destroy the opponent with surface-to-surface missiles. In the latter game, players may have far greater latitude in choosing the theaters of military action and the forces committed to those theaters.

Because the guidelines, bounds, and subtle influences of scenarios can become straightjackets to players' decisions, the game designer must be sure that the scenario allows sufficient freedom of action within which the game's objectives can be met. Because game objectives should generally focus on exploring the factors and reasoning affecting specific types of decisions, those decisions must be presented to the players with alternatives that have not already been precluded merely by the scenario restrictions.

For example, one goal of a game may be to study the factors affecting the relative allocation of Navy forces to the defense of sea lines of communication (SLOC) and to forward offensive operations. In this case, the scenario must at least define a potential threat to the SLOC and a potential benefit to offensive operations so that choices between the alternatives may be made for strategic or operational reasons, not merely by default. Similarly, if a game seeks to explore operations in a global war with the Soviet Union, scenarios that assume away the existence of tactical nuclear weapons may introduce severe biases in player decisions. With no possibility of a nuclear threat, forces may

be operated in ways that are highly unlikely if the threat of escalation is a real one.

Research into the roles, desirable characteristics, and evaluation of scenarios is ongoing (see, for example, [5 and 6]). For game designers, the most important elements of this research deal with identifying some of the basic components of a scenario and defining some principles of scenario design.

Simply stated, a scenario should include all essential information about the game's setting, and subsequent planned modifications to it, and should contain no superfluous information. For example, a game dealing with submarine tactics in the Arctic will seldom require a scenario that defines the balance of land-based tactical air power in the Indian Ocean. The trick for the designer is to determine what is essential and what superfluous.

The scenario is the common starting point from which sponsors, players, analysts, and other game participants address the goals of the game. As such, the scenario must provide a description of the context or background from which it arises, including the general physical and geopolitical situation. It should also include the attitudes, goals, and intentions of the actors involved, whether friendly, enemy, or third-party. Of course, such information should be limited in quantity and quality to reflect real-world uncertainty and inaccuracy.

In addition to background information, scenarios should also include guidance to each player or cell about specific objectives or missions those players may be called upon to pursue. Command relationships among players and cells and between players and control should be clearly spelled out, as should the assignment of forces and support. When updates to any or all of these elements of a scenario are planned, such updates themselves should be considered part of the scenario, though obviously they should not be provided to all the players beforehand. Similarly, if the control team must respond to player actions or requests (such as requests for nuclear release) in specific ways for the game objectives to be met, such instructions are considered part of the scenario.

Table 2 summarizes the primary components of a wargame scenario. Designing a scenario consists of tailoring the components listed in table 2 to

create an environment in which the objectives of the game can be met. Good design practice involves four fundamental principles:

- Understanding the problem
- Building from the bottom up
- Documenting choices
- Communicating results.

TABLE 2

COMPONENTS OF SCENARIOS

1. Background
   - Situation
   - Attitudes
   - Intentions
   - Goals
   - Physical conditions
2. Objectives or missions
   - All players and cells
3. Command relationships
   - Among players and cells
   - Between players and control
4. Resources
   - Force structure
   - Available support
5. Updates during play, and control team instructions

The first and most basic principle—understanding the problem—is perhaps the one most frequently violated, possibly because it is so obvious. As with everything else in a game's design, the scenario begins with the game's objectives. But just understanding the objectives is not enough; the scenario designer must also understand how those objectives are to be met in the game. He must identify the kinds of player activities and decisionmaking opportunities that are required to meet game objectives, and then he must ensure that those activities and opportunities can arise.

For example, in the surface-to-surface missile game described earlier, possible game objectives of teaching proper radar-targeting procedures require that the target be detectable. The scenario writer must choose a physical and tactical environment to ensure this possibility. Placing the target in a radar shadow zone may teach valuable lessons about real-world tactical possibilities but will make it difficult to achieve the radar-targeting goals.

Once the game's objectives and means for achieving them are thoroughly understood, the scenario writer may begin to structure the flow of game play to allow the means and ends to come together without forcing the players to follow a single, rigid path. Decision points must be defined in enough detail to allow players to identify a realistic range of alternatives while restricting that range to a reasonably limited type or number so that game control personnel can be adequately prepared to evaluate any player decision.

The key to this process is a bottom-up, hierarchical approach. The designer begins by identifying the specific sorts of decision points required to meet game objectives. He then must step back in time to determine the possible sequences of events that could lead to such decision points. In this process, the designer seeks to identify critical events, decisions, or actions that are required to reach the particular decision point and that are beyond the control of the players. Such events are then incorporated into the scenario. In many cases, these considerations shape both scenario updates during play or control team instructions.

As an example, consider a wargame designed to explore global war-fighting issues. A critical issue in any global war is the decision to employ nuclear weapons in any form. It may be the case that allowing such weapons to be used would be contrary to achieving many game objectives or would make the combat-evaluation tasks of the control personnel too difficult or speculative. One solution to this problem, and unfortunately the one most frequently employed, is for the scenario to explicitly tell the players that

nuclear weapons will not be used. A better alternative to simply assuming nuclear weapons away might be to acknowledge their existence and possible employment in the scenario background information provided to the players but to instruct the control team to refuse nuclear release should players request it. The overall effect, that nuclear weapons are not used, is the same. However, the latter approach will allow both investigation of conditions under which nuclear release may be considered and exploration of effects such possibilities might have on conventional warfare operations.

The bottom-up approach allows the scenario designer to build in and constantly monitor the completeness, coherence, and credibility of the scenario. A complete scenario provides all those involved in the game and its analysis the information they require to carry out their roles. If a theater commander is not given a mission, the scenario is incomplete. If an analyst is not told why the war begins, the scenario is incomplete. In addition, completeness of the scenario allows participants and future students of the game to "appreciate the objectives and scope of the ... [game] as well as the subtle issues it poses" [5], and to separate those issues built into the game by the scenario and those issues arising from the play of the game itself.

Coherence of scenarios means scenario assumptions must also be logically consistent, but goes beyond that. A coherent scenario considers all the elements of the game, from its objectives, to its mechanics, to its analysis, and helps the pieces fit together. If an important objective of the game is exploration of under-ice antisubmarine warfare operations, a coherent scenario will assure not only that such operations will take place, but also that they will take place in ways that can be handled by the game's mechanics and that can be recorded and interpreted by the game's analysts.

Finally, a scenario must be credible in the sense that game participants and later audiences for its results are willing to suspend disbelief. The scenario represents a view of a possible reality. That reality need not be the most likely one but should generally be a possible one. As [6] suggests, the starting point should be current reality, and the development of the scenario's fiction should proceed logically from that reality according to the documented decisions and assumptions of the scenario designer. Some elements of the scenario world may be perceived as extremely unlikely, if not impossible (as, for example, the games played at the Naval War College between World War I and World War II that pitted the U.S. and British fleets against one another). However, if those elements most applicable to the objectives of the game are perceived as important and in need of exploration, the suspension of disbelief

can still be achieved. (The need to study tactical alternatives against a superior fleet, using existing systems, allowed players to overcome their skepticism about a U.S./U.K. war at sea.)

Throughout the scenario design process, it is important for the designer to document his decisions. He should record the reasons behind his choices of assumptions, the factors included or excluded from the scenario, the use of particular sources of information, and any other decisions he makes. Thorough documentation allows the designer to be sure of just what went into the game, especially if there are likely to be questions about what comes out of it. And thorough documentation provides a solid basis for the final and (in many ways) most crucial element of the scenario process.

To be of any use, a game scenario must be communicated to the people who will use it. There are basically five classes of such users: game sponsors, game control personnel, game players, game analysts, and future audiences for game reports or other summaries. Sponsors need to be sure that the scenario will facilitate meeting the game's objectives. Control personnel need to understand the context of the game and the prerogatives and limitations under which they must operate. Players need the same information as control personnel, but constrained to reflect their less-than-perfect knowledge of their game-world. Analysts need not only the full story of what and why, the "ground truth," but also the story as told to players and control so that they may interpret the effects of information constraints. Finally, the future consumers of the game's issues must know not only the context of the game, but also how to distinguish scenario input from game-play output. Communicating effectively to such diverse groups requires not only literary and graphical skills, but first and foremost the complete information provided by thorough documentation, subsets of which can be tailored for particular groups.

Table 3 summarizes the key elements of the scenario design process.

Data Base

As described above, a wargame scenario contains largely qualitative information about the state of the world in which the game takes place. The data base of the game contains the quantitative information about capabilities of forces, levels of logistics, and relative likelihoods of the occurrence and outcome of interactions between forces. The data base links the scenario

and the mechanics of the game. It must provide all the inputs required to allow the game's models to reproduce the qualitative scenario conditions and to generate outcomes of interactions.

TABLE 3

ELEMENTS OF SCENARIO DESIGN

1. Understanding the problem
    - Game objectives
    - How scenario affects achievement
2. Building from the bottom up
    - Define decision points
    - Hierarchy of information and assumption
    - Completeness, coherence, credibility
3. Documenting choices
    - Reasons for assumptions and decisions
    - Sources of information
4. Communicating results
    - Sponsors, control, players, analysts, audience
    - Tailored subsets of information

But a good data base is more than raw, unprocessed inputs. Many current games suffer from the fact that players are provided a mass of raw

data that contains much superfluous information. In turn, important data are difficult to find or require detailed calculations that are impractical for the player to carry out during the game. Players representing a battle force or fleet commander seldom need to know the cruise speed of a Harpoon. On the other hand, they often want to know the chances of a successful Harpoon strike.

The data base provided to the players should be tailored to their game role, to the types of decisions they should be making, and the types of information they need to make those decisions. More detailed data are required by control teams and umpires and can be made available to the players if the situation warrants it. Furthermore, actual commanders are likely to have access to quantitative analyses of raw data that would give them estimates of capabilities or chances of success in many situations. The shortage of similar capabilities in a game makes the player's job much harder. The use of analyst-players to fulfill the function is one solution. Another is the use of extensive preprocessing of raw data. Employment of either of these options makes for a more realistic and more efficient decisionmaking process. Preprocessing data can also greatly help in the suspension of disbelief. If players are aware of the range of possible outcomes of their decisions and have some idea of relative likelihoods, they will be more willing to accept an unlikely result for what it is.

A simple preprocessing technique that can be applied in many areas of gaming involves developing graphs for various types of interactions. These graphs can display the sensitivity of outcomes to uncertainties in critical factors. Players can be provided with such graphs and can make decisions based on their perception of the values of the key parameters. This perception can be based on their own experience, on analysis, and on information provided in the data base or a combination of all of those. The actual interaction is then resolved using the same graphs but with inputs selected by the umpire using prechosen values or predefined procedures.

For example, figure 1 shows a generic graph depicting aircraft attrition against different levels of air-defense capability. For each level of capability, a range of uncertainty is shown. The player may be planning to strike a target that his intelligence personnel estimate to have a low-defense capability. He can then determine that his losses are likely to lie between X and Y. If the strike is made and losses of level Z occur, instead of complaining about an unrealistic model, he may be led to believe that his intelligence people underestimated enemy defenses.

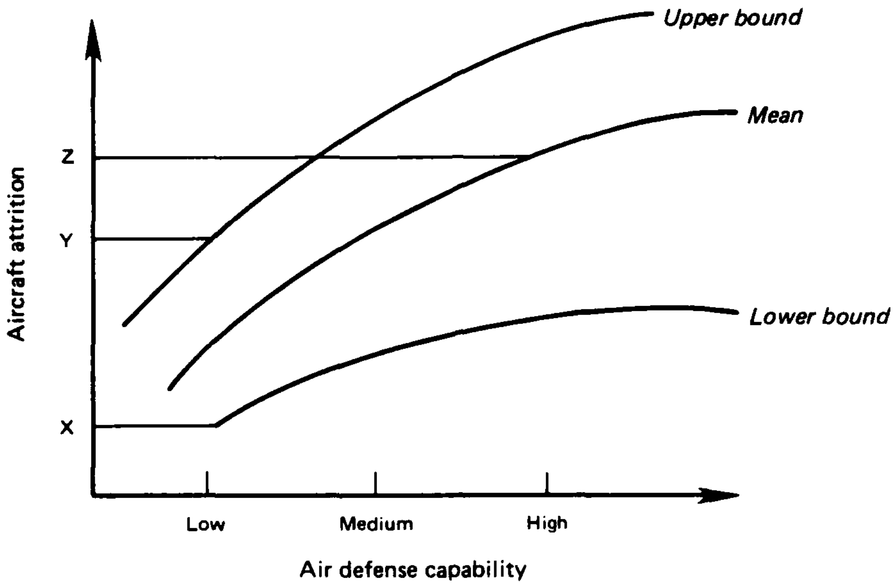


FIG. 1: EXAMPLE OF PREPROCESSED DATA

Of course, preprocessing data in this manner requires much preparation prior to game play. In detailed tactical-level games in which there are large numbers of parameters to vary over wide intervals, extensive preprocessing may become impractical. However, the computing resources readily available to most wargaming facilities are powerful enough that graphical displays for at least some aspects of the game play can be developed fairly easily and quickly. Such an approach speeds up actual game play by limiting the real-time use of complex models, relegating those to the preprocessing phase of game design. Actual game play would then only require random number draws to access specific results or special model runs for cases well beyond the bounds of the preprocessed data.

DEVISING THE MECHANICS

If the scenario sets the stage for the game, and the data base provides the information required for players to make decisions, the game's mechanics

allow those decisions to be implemented and inform the players about their effects. Wargame mechanics may be considered as two interrelated systems: models and procedures. The models translate data and decisions into game events. Procedures define in game terms what players can and cannot do and why, sequence the game events to allow for accurate re-creation of cause and effect, and manage the flow of information to and from players and control.

Models

Wargames use models as representations of all the aspects of reality the game may be required to simulate. These models may take various forms. Some of the earliest wargames relied largely on the judgment of experienced professional soldiers and sailors, as reported in [7]. Modern games often employ complex mathematical expressions programmed into high-speed computers. A wargame's models and the results they produce are best considered as inputs to the game, devices to move game play along rather than measures to evaluate player success or failure. Specific model needs vary from game to game. Some of the broad categories of models most likely to be required in wargames are the following:

- Physical environment
- Kinematics
- Intelligence collection and dissemination
- Command, control, and communications
- Sensors
- Weapons
- Logistics.

No matter what the form or subject of wargame models, good ones share the following key characteristics:

- Accurately reflect factors most prominent for player decision levels
- Flexible enough to deal with unusual decisions

- Adaptable to changes in the data base
- Stochastic to the extent reality is stochastic
- Documented to allow others to understand assumptions and algorithms.

Chief among these characteristics is the need to accurately reflect the impact of those factors most prominent in the decision processes of the game's player roles. Other factors, many of which may be important to the outcome of an actual event, are aggregated rather than assumed away. For example, a battle force commander may determine the size and composition of an air strike. Attacker and defender tactics during the strike, while critical to the outcome in the real world, are beyond the direct influence of the commander and so may be aggregated in the wargame's model of strike resolution.

There are two basic approaches to using models in wargames. The first approach employs detailed models to preprocess data before the game is played (as described in the previous section). Complex calculations or judgments are used to prepare tables and graphs of outcomes as simple functions of player decisions. These tables and graphs become the models actually used during game play. This approach was popular in gaming before the advent of high-speed computers. For example, a wargame employed during the late nineteenth or early twentieth centuries might use data from fleet gunnery ranges, ballistics calculations, and measures of armor penetrability to devise tables showing the probability that a round fired from a battleship's main battery would disable the turret of an opposing ship at various ranges. This approach has the advantage of transparency (players can easily see what the relative odds of various outcomes are), ease of use, and direct applicability to player decisionmaking. It has the disadvantage of being limited to precalculated cases, requiring umpires to interpolate or extrapolate from the given cases when circumstances in the game differ from the assumed conditions.

Modern computing capabilities allow the option of using a second modeling approach. This approach uses the complex models to calculate results during actual game play. If a battle group is attacked by missile-carrying aircraft, the precise composition of the opposing forces and their sensor and weapon capabilities can be entered into a computer model. The model can account for battle group formation, attack spacing, and many other parameters. It can calculate losses to aircraft and different types of damage to

each target ship. The use of such detailed models has the advantage of appearing to better replicate the precise conditions of game play in the assessment of outcomes. However, the price to be paid is that the players can no longer see the relative odds generated by the models and so find it difficult to incorporate expectations about outcomes into their decisions.

Another disadvantage of the use of detailed, complex models during game play is often a severe slowing down of play. This phenomenon, discussed in more detail in [2], can result from the need for providing detailed models with detailed inputs, requiring detailed planning. Inevitably, such micro-modeling of reality results in more time spent on processing interactions.

Thus, when surveying the models available for use or defining those that need to be devised, the wargame designer must balance the advantages and disadvantages of the two modeling approaches. Part of the art of game design lies in choosing the best mix of approaches and models to maximize advantages while playing down the problems. Often, however, the design solution must go beyond the models themselves to the procedures through which those models are applied to the play of the game.

Procedures

Scenarios, data bases, and models are all necessary components of a wargame, but it is the procedures for their orchestrated use that set the game in motion and keep it on track. These procedures are specified by what are sometimes known as the game's rules, and are usually monitored by a team of umpires, referees, or controllers. These umpires and the procedures they employ have three main functions. These functions, based on [7], are listed in table 4.

Umpires and procedures translate player decisions into game terms. If a battle-group commander decides to launch an air strike, there must be a procedure for determining which aircraft are available for the strike and how long they will take to reach their target. The umpires must enforce the dictates of the game's rules and models. If the rules require a ship to lose its weapons capability after a missile hit, the umpires must ensure that this requirement takes effect. Umpires and procedures must also prevent physically unrealistic actions or sequences of events. Ships may not sail over land, nor may a column of tanks cross a river before a bridge is built to carry them. In carrying out these functions, however, umpires must avoid forcing the players

to play the game the way the umpire or sponsor would have played it. Procedures must establish wide yet realistic bounds within which the players must be free to try their own ideas.

TABLE 4

FUNCTIONS OF PROCEDURES AND UMPIRES

- Monitor player actions
  - Translate player actions into game terms
  - Enforce the rules of the game
  - Prevent physically unrealistic actions or sequences of events
- Assess interactions
  - Use models, data, and rules
  - Use judgment when required
- Inform players about action outcomes
  - Employ realistic limitations
  - Introduce "fog of war"

Assessing the outcomes of game events is the second major task of procedures and umpires. Player decisions about the movement and use of forces, sensors, and weapons must be evaluated for the possible interactions they might cause. Typically, the results of such interactions are assessed using the game's models and the judgment of the umpires. Procedures for determining model inputs and interpreting model results are often required when special-purpose models are not developed for a specific game.

Finally, players must be informed about the results of interactions. While open games, discussed earlier, provide players full information, closed

games limit player knowledge of the results of interactions in ways consistent with player ability to learn about the actual situation. If there are no sensors available to determine the effectiveness of a long-range missile strike, players should receive no information. If the main sources of damage reports for an aircraft strike on an enemy surface force are aircrew debriefs, the potential inaccuracies of such debriefs should be specified in the game rules and applied by the umpires. Time delays for the acquisition, interpretation, and communication of intelligence reports should be similarly specified in the game's rules.

One of the most crucial of game procedures – management of time – cuts across and affects all of the functions listed in table 4. Time is a critical aspect of any wargame, and the effective treatment of time is an essential ingredient in any good wargame design. There are two reasons why this is so. First, in reality, timing and speed of execution are often decisive in determining the success or failure of a military operation. Second, time management in a game very often determines the extent of activity that the game can explore.

In games such as chess, player activity is sequenced in a series of alternating turns or moves. This same terminology is applied to wargames, but in wargames, moves "represent definite periods of real-world time, ... [and the] length of a move is the interval of time for which decisions and evaluations are made" [7]. There are three basic approaches to defining the length of a move. One approach uses a game clock that runs continuously and that may be set to run either faster or slower than real time. The other approaches operate on blocks of time rather than on a continuous clock.

Strictly speaking, a continuous-time game does not really have moves in the sense that term generally implies. In such systsems, like the one used by the NWGS, players give orders and forces attempt to execute those orders continuously. There are many advantages to the continuous approach, especially because it appears to be more faithful to reality and is more likely to produce the kind of dynamic interactions that occur in real operations. The price lies in potential distortions, especially in the planning process, when the game-time to real-time ratio (or game rate) is not one-to-one. If game time is speeded up (as is the usual case in operational or strategic games like [2]) so that 1 minute of game play represents several minutes of real time, players may find that realistic planning of operations takes too long in game terms and is replaced by seat-of-the-pants or reactive decisionmaking. At the other extreme, if the game clock is slowed down (as is most likely in tactical-level games) so that players may study a situation more carefully before acting, a

false impression of the effects of time pressure may easily result. In large and complex games like the Global War Game [2], some commands may be more heavily engaged than others, requiring slower clock speeds. This phenomenon can force overall game play to run at the slowest speed, or to fragment into multiple "time-lines," thus making game control more difficult.

Alternatives to the continuous-time approach define the amount of game time each move represents and execute the move as a block of time rather than in a continuous fashion. For example, a game may define a single move to represent an entire day's operations; the sequence of events within the day would then be evaluated by umpires or some other system device.

There are two fundamental approaches to incremental time games. The first approach defines "the smallest practical period of time ... and all moves in the game are of that length" [7]. This approach is standard in hobby wargames, in which a game turn may represent any span from 30 seconds (in a game of tactical air combat) to 3 months (in a strategic-level World War II game). This fixed-span approach is usually most successful when the span of time each move represents corresponds to the amount of real time the player roles would normally require to collect information, interpret it, make decisions, and implement those decisions.

The second approach to time-increment moves is more flexible; moves may represent varying amounts of real time depending on the importance and intensity of activity expected during a given span. For example, a prehostilities move may encompass 10 to 15 days of activity. The D-day move of the same game may represent just a single day (see [4] for an example of such a move structure). Variable length moves may be predetermined in the game's design or dynamically defined during game play. In the former case, the designer may use the scenario, likely player actions, and game testing to decide on the length of each move. In the latter case, the game director "estimates the time of the next critical event and calls for a move of corresponding length" [7]. In some situations, the second approach can be used even in fixed-move games. If moves are specified to be 1 day in duration but control personnel believe that there will be little activity for several days, multiple moves may be conducted as a block. Care must be exercised, of course, to prevent distortions whenever play goes beyond the game's intended design in this manner.

Finally, there are two approaches for dealing with the amount of real time players expend in making a move. Most Navy games predefine the time

allocated to each move in order to assure the completion of all planned moves. For example, two moves per day, one in the morning and one in the afternoon, is a fairly standard scheme. The alternative, again frequent in hobby gaming, allows each move to proceed at its own pace, some going quickly and others moving slowly. Not surprisingly, fixed time allocated for moves is often associated with variable-length moves; free time is often associated with fixed-length moves.

All of these various approaches to event sequencing and time management seek to balance the need to play the game expeditiously, both to prevent player boredom and to explore slow-developing issues, and the need to give players enough time to plan their actions and prevent unrealistic time constraints. The choice of approach to defining moves and allocating time to play them is a critical design decision. As with most such decisions, a judicious use of all the available approaches is often necessary.

Clearly, the full range of rules and procedures for any game can vary from the few and simple to the many and complex. The game designer should detail the required procedures and specify the structure of any computers, control group, or umpire team needed to monitor them.

Because of the potential complexities of game procedures and the demands placed on umpires or automated control systems, many wargaming centers have established a staff of control personnel, such as that at the Naval War College's War Gaming Department. Usually such groups have well-defined standard operating procedures. If designing a game for use at such a facility, the designer should try to conform to such procedures unless there are compelling reasons to do otherwise. If modifications to the game design or to the facility's standard procedures become necessary, they can be detected in a well-structured development process.

GAME DEVELOPMENT

Just as a research paper benefits from being edited prior to publication, even a well-designed wargame benefits from the game development process. This process, which may or may not be a formal one, seeks to assure that the game design is complete and is capable of meeting the sponsor's objectives. Table 5 summarizes the goals and phases of the game development process.

TABLE 5

GOALS AND PHASES OF THE WARGAME DEVELOPMENT PROCESS

Goals – ensure that

- The pieces of the game do what the designer intends
- All necessary pieces are available
- The pieces fit together
- The entire game functions smoothly
- Sponsor's objectives can be met
- Game responds to expected actions in expected ways
- Game can deal with unexpected actions efficiently

Phases

- Model, data, and scenario validation
- Playtesting
- Preplay

The first goal is to verify that the individual elements of the game actually do what the designer expected or intended. This goal most obviously applies to any mathematical combat models used in the game. The

performance of such models, especially when complex and computerized, should be carefully checked to ensure they are actually operating in accordance with the specified structure. Such checks include program "debugging" and running of test cases. Similar checks for internal consistency of scenario assumptions should also be carried out.

The development process must also try to ensure that the game design is complete. All data and models likely to be needed should be available. All foreseeable political decisions by control team members should be specified. If the game is likely to include submarine operations in the South Atlantic, for example, the appropriate data for South Atlantic operating conditions should be in the data base.

After making sure that the game's pieces work as designed and that all needed pieces are available, game development must then test to see whether they all fit together. An outer-air-battle model might produce the number of enemy missiles penetrating to the missile-defense zone, but if the air-defense missile model also requires the time and altitude separation of those missiles, the pieces do not fit together. Game development also attempts to polish the game's mechanics so that the entire game functions smoothly.

Perhaps the most important and difficult task of wargame development is to ensure that the game will allow the sponsor's objectives to be met. This may seem an obvious goal and one unlikely to elude the game's designer, but it is not impossible for the design process itself to obscure the purposes for which the design was originally undertaken. For this reason, development of the game should usually be overseen by someone other than the game's designer.

Finally, and key elements in the entire development process, the game's responses to the extremes of player decisions must be exercised. Expected decisions should produce expected responses by the game system, though not necessarily expected outcomes from stochastic combat models. Unexpected player decisions should not cause the game system to self-destruct.

As described above, the development process is composed of three elements. First and most basic is the model, scenario, and data validation phase. Last is the game preplay phase. Both of these phases are seen in virtually all Navy wargames. Too often overlooked is a middle phase, that of playtesting. The concept of playtesting is a familiar one in commerical wargaming. As the

word implies, playtesting combines actually playing the game with a very thorough testing of its functions.

Playtesting involves playing the game as the designer intends, but usually without the actual participants. Instead, playtesters assume the roles of those participants and attempt to test the functioning and the limits of the game. The integration of the various game elements is exercised and refined. Not only must the playtesters check to see if the game works as expected, but they must also try their best to make the game break down. Problems with the system, procedures or data that this process discovers, can then be corrected before the actual play of the game.

The importance of the testing aspect of the playtesting phase cannot be overemphasized. Thorough testing cannot guarantee a problem-free game. Insufficient testing almost certainly increases the chances of having to cope with unforeseen difficulties during play. Unfortunately, thorough playtesting requires the allocation of more time to the entire game preparation cycle and the commitment of personnel to the playtest process.

The last step of game development is game preplay. Preplay is a kind of "dress rehersal" for the game, as described in [8]. Game control personnel play through the game, generally in an abbreviated fashion, to familiarize themselves with their responsibilities and some of the situations they may have to address during the upcoming play of the game.

Because of the great demands of thorough playtesting, it is sometimes necessary to combine playtesting and game preplay. As practiced at the Naval War College, preplay seeks not only "to check the NWGS computer play file of information, to validate [the] data base and, most importantly, to prepare the WGD control-group personnel ... for the upcoming game ... [but also] to expose difficulties or omissions in preparation prior to the arrival of the players" [8]. The War College has been remarkably successful with this compressed approach, but the difficulties of adequately carrying out both testing and preparation often leave the testing function to take a back seat.

WARGAME PLAY

All the efforts of game sponsors, designers, and developers described in the preceding sections are directed toward producing a game system. The game itself takes shape only when the players enter the scene. Players must understand that the success and value of the game revolves around them. It is their decision processes, not the game's models, that are the key subject of the game's investigation and analysis. Good game play requires adequate preparation, appropriate role playing (the willing suspension of disbelief), and critical post-game commentary about game substance and process and their interaction.

PREPARATION

Officers assigned to play roles in a wargame should be provided with preliminary information about the game's objectives, scenario, and any other relevant information as soon as such information is available in usable form. Players should study this information and ask game personnel for details and clarifications about any questionable areas.

As the date of the game approaches, command players are usually asked to prepare an outline concept of operations and provide it to the game control staff. The control staff will use this concept to help test and prepare for game play.

In addition, players should consider what assistance they might require to carry out their game role. Subordinates or staff manning levels, information needs, and the modes of information access both before and during play (for example, player desire for daily operational intelligence briefs) should be specified when possible. If particular reference publications are desired, players should verify their availability at the game site and make arrangements to bring or send those materials not provided.

Finally, it can be very helpful to game control personnel if players can identify those types of decisions the player intends to reserve to himself and those he intends to delegate to the controllers. Often, the game control group will ask players to provide some or all of the above information prior to the start of the game, while other information is required only after play has

begun. Players should realize that providing such information is an important aspect of game-play responsibilities.

ROLE PLAYING

Once players arrive at the game site and the game is actually underway, the most difficult and important task facing those players is to stay in their role as much as possible and to force others to do the same. If the player is a fleet commander, he should generally refrain from specifying what targets a particular missile ship should engage during an incoming air attack. Similarly, he should remember that he is subject to the orders of the National Command Authority and should take no unrealistic actions to avoid carrying out such orders.

Typically, the most difficult time for all players and controllers to keep within their roles occurs when assessment results are reported, especially when those results differ from player expectations. If an air strike against enemy shore targets results in extraordinarily high losses, the players should certainly request some explanation. But the request, and the response, should be couched in operational terms, not in game terms. To complain about the workings of a model is seldom productive during game play. A well-designed game and well-prepared control staff will not produce or report assessment results beyond the bounds of possibility. Failures of reconnaissance, poor tactical execution, or misestimation of the enemy are to be expected in warfare and should and will be reflected in game play as well. So, too, will the extraordinarily favorable circumstances players sometimes overlook when pleased with a successful outcome.

Sometimes, the game control staff will fall into the trap of reporting results of models rather than results of combat. Players should point out such observations or failures of the staff to maintain the game's illusions. Perhaps the most frequent abuses lie in unrealistically detailed reports of damage to enemy forces and facilities.

POST-GAME COMMENTARY

Nearly all Navy wargames conclude with a "hot wash-up" during which some or all of the players are asked for an overall assessment of the game and for specific comments. Some games, in addition, allow for an ongoing series of

such sessions during game play. Players should make the most of these chances to directly influence what the game produces.

Hot wash-up briefs and other commentaries are the player's major opportunity to discuss the key elements of his decisions. They also give the player the chance to address directly the sponsor's objectives for the game. Because of their importance, players should attempt to base their presentations on notes taken during or immediately after the heat of the action. Such a "battle diary" can help players distinguish their actual thoughts and rationales during the game events from post-event analysis and "hindsighting."

Comments about the mechanics or process of the game should also be made. If invited for open discussion, such comments may be appropriate for a hot wash-up. In other cases, players may be asked to fill out comment sheets. All such remarks are helpful in the refinement and further development of games and game systems. The most useful comments are usually those that can be related to specific game situations and show the effects the process of the game may have had on the substance.

PLAYING THE THREAT

Playing non-U.S. or "threat" roles in a wargame is not much different from playing friendly or "Blue" roles. However, playing the threat *well* requires special effort and often special training or expertise. "Red" players must understand not only the technical capabilities of the opposition, but their tactical doctrine as well. To "play Red," the player must learn to "think Red."

For this reason, established gaming facilities usually have a special team of Red players. At the Naval War College, for example, there is a special detachment of the Naval Operational Intelligence Center whose responsibilities include playing Red in accordance with intelligence projections of enemy capabilities and intentions.

However, Red players must be careful not to restrict themselves to the "standard" or accepted responses to every Blue action. Where uncertainties and debates exist, different approaches can be used in different games. When specific situations seem to call for slightly more imaginative responses, Red players should sometimes be willing to deviate from overly rigid interpretations of enemy "doctrine." When they do so, however, they should carefully

explain their rationale and inform the players that what they did may not be in accord with strict intelligence interpretations of likely threat behavior. Of course, any such unusual actions must be consistent with game objectives or they are likely to be disallowed by the game sponsor.

REFERENCES

[1] National Defense University, *The Academic Uses of Politico-Military Simulation*, by Frank J. Dellerman, LCol., USAF, Unclassified, Apr 1985

[2] CNA Research Memorandum 84-45, *An Analyst's View of Global War Game 84* (U), by Peter P. Perla, Secret, Dec 1984

[3] CNA Research Memorandum 85-54, *Central Front/Maritime Option Seminar Wargame* (U), by Darryl Branting and Aloysius Hepp, Secret, Aug 1985

[4] Chief of Naval Operations, OP-095, *POM-87 War Game Report* (U), Secret/NOFORN, Jun 1985

[5] Pace, Dr. Dale K., "Scenario Use in Naval System Design," *Naval Engineers Journal*, Vol. 98, No. 1, Jan 1986

[6] Rand Corporation, Rand Note N-1855-DNA, *Toward a Calculus of Scenarios*, by Carl H. Builder, Unclassified, Jan 1983

[7] U.S. Naval War College, *Fundamentals of War Gaming*, 3rd edition, by Francis J. McHugh, Unclassified, Mar 1966

[8] Euliss, James P. II, Cdr., USN, "Wargaming at the U.S. Naval War College," *Naval Forces*, Vol. 6, No. V, 1985

CNA PROFESSIONAL PAPER INDEX[1]

PP 407[2]
Laird, Robbin F. *The French Strategic Dilemma*, 22 pp., Nov 1984

PP 415
Mizrahi, Maurice M. *Can Authoritative Studies Be Trusted?* 2 pp., Jun 1984

PP 416
Jondrow, James M., and Levy, Robert A. *The Displacement of Local Spending for Pollution Control by Federal Construction Grants*, 6 pp., Jun 1984 (Reprinted from *American Economic Review*, May 1984)

PP 418
Reslock, Patricia A. *The Care and Feeding of Magnetic Tapes*, 7 pp., Jul 1984

PP 420
Weiss, Kenneth G. *The War for the Falklands: A Chronology*, 32 pp., Aug 1982

PP 422
Quester, Aline, and Marcus, Alan. *An Evaluation of The Effectiveness of Classroom and On the Job Training*, 35 pp., Dec 1984. (Presented at the Symposium on Training Effectiveness, NATO Defense Research Group, Brussels, 7-9 January 1985)

PP 423
Dismukes, N. Bradford, and Weiss, Kenneth G. *MARE MOSSO: The Mediterranean Theater*, 26 pp., Nov 1984. (Presented at the Seapower Conference, Washington, D.C., 26-27 November 1984)

PP 424
Berg, Dr. Robert M., *The CNA Ordnance Programming Model and Methodology*, 27 pp., Oct 1984. (Presented at the ORSA-MAS/MDRS Symposium, Washington, Aug 1984)

PP 425
Horowitz, Stanely A., and Angier, Bruce N. *Costs and Benefits of Training and Experience*, 18 pp., Jan 1985. (Presented at the Symposium on Training Effectiveness, NATO Defense Research Group, Brussels, 7-9 January 1985)

PP 427
Cavalluzzo, Linda C. *OpTempo and Training Effectiveness*, 19 pp., Dec 1984. (Presented at the Symposium on Training Effectiveness, NATO Defense Research Group, Brussels, 7-9 January 1985)

PP 428
Matthes, Greg, Cdr., USN and Evanovich, Peter *Force Levels, Readiness, and Capability*, 24 pp., Nov 1984. (Presented at the ORSA-TIMS 26-28 November Meeting, Washington, D.C.)

PP 429
Perla, Peter P. and Barrett, Raymond T. LCdr., USN, *Wargaming and Its Uses*, 13 pp., Nov 1984. (Published in the Naval War College Review, XXXVIII, No. 5 / Sequence 311, September-October 1985)

PP 430
Goldberg, Matthew S. *The Relationship Between Material Failures And Flight Hours: Statistical Considerations*, 18 pp., Jan 1985

PP 431
McConnell, James M. *A Possible Change in Soviet Views on the Prospects for Anti-Submarine Warfare*, 19 pp., Jan 1985

PP 432
Marcus, Alan J. and Curran, Lawrence E., Cdr., USN. *The Use of Flight Simulators in Measuring and Improving Training Effectiveness*, 29 pp., Jan 1985 (Presented at the Symposium on Training Effectiveness, NATO Defense Research Group, Brussels, 7-9 January 1985)

PP 433
Quester, Aline O. and Lockman, Robert F. *The All Volunteer Force: Outlook for the Eighties and Nineties*, 20 pp., Mar 1984. (To be published in *Armed Forces and Society*, 1985)

PP 435
Levine, Daniel B. and Jondrow, James M. *Readiness or Resources: Which Comes First?* 12 pp., Mar 1985

PP 436
Goldberg, Matthew S. *Logit Specification Tests Using Grouped Data*, 26 pp., Jan 1985

1. CNA Professional Papers with an AD number may be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151. Other papers are available from the Management Information Office, Center for Naval Analyses, 4401 Ford Avenue, Alexandria, Virginia 22302-0268. An index of selected publications is also available on request. The index includes a listing of professional papers, with abstracts, issued from 1969 to December 1983).
2. Listings for Professional Papers issued prior to PP 407 can be found in *Index of Selected Publications (through December 1983)*, March 1984.

CNA PROFESSIONAL PAPER INDEX (Continued)

END
9-87
DTIC